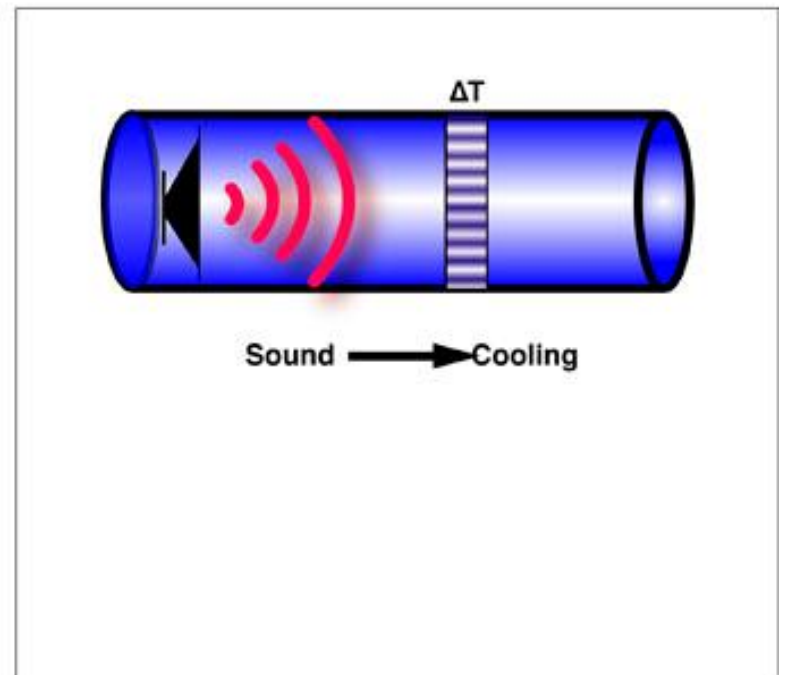
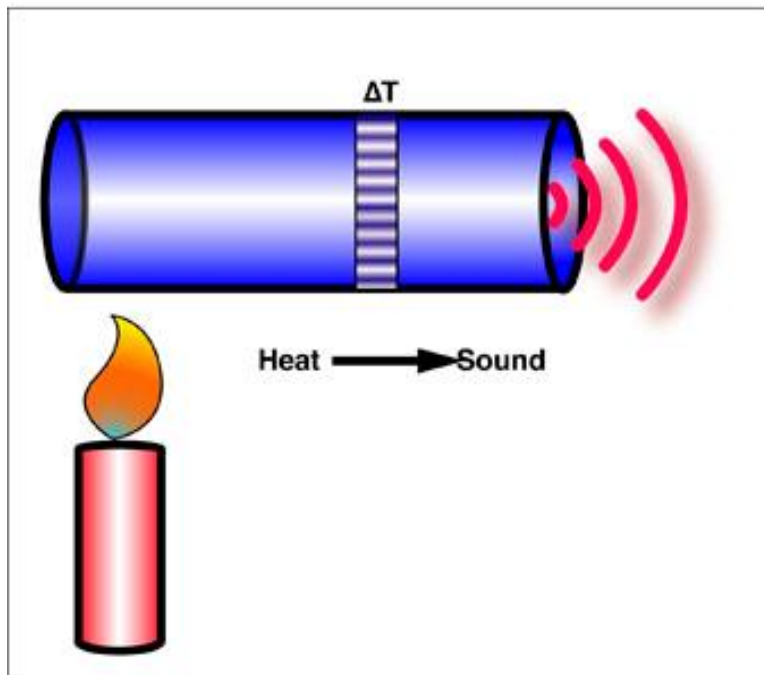
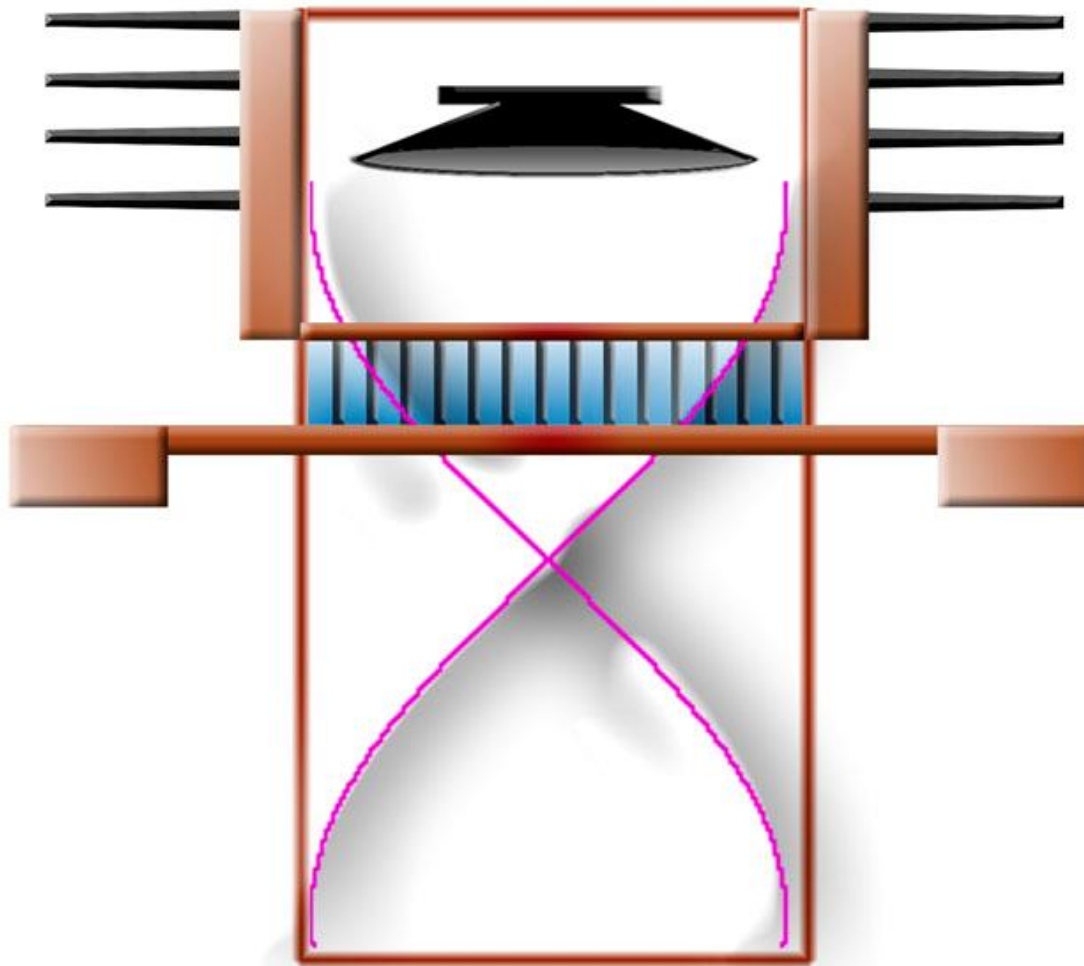


**CENTER
FOR
ACOUSTIC COOLING TECHNOLOGY**

**Dept. of Physics
University of Utah
Salt Lake City, UT**

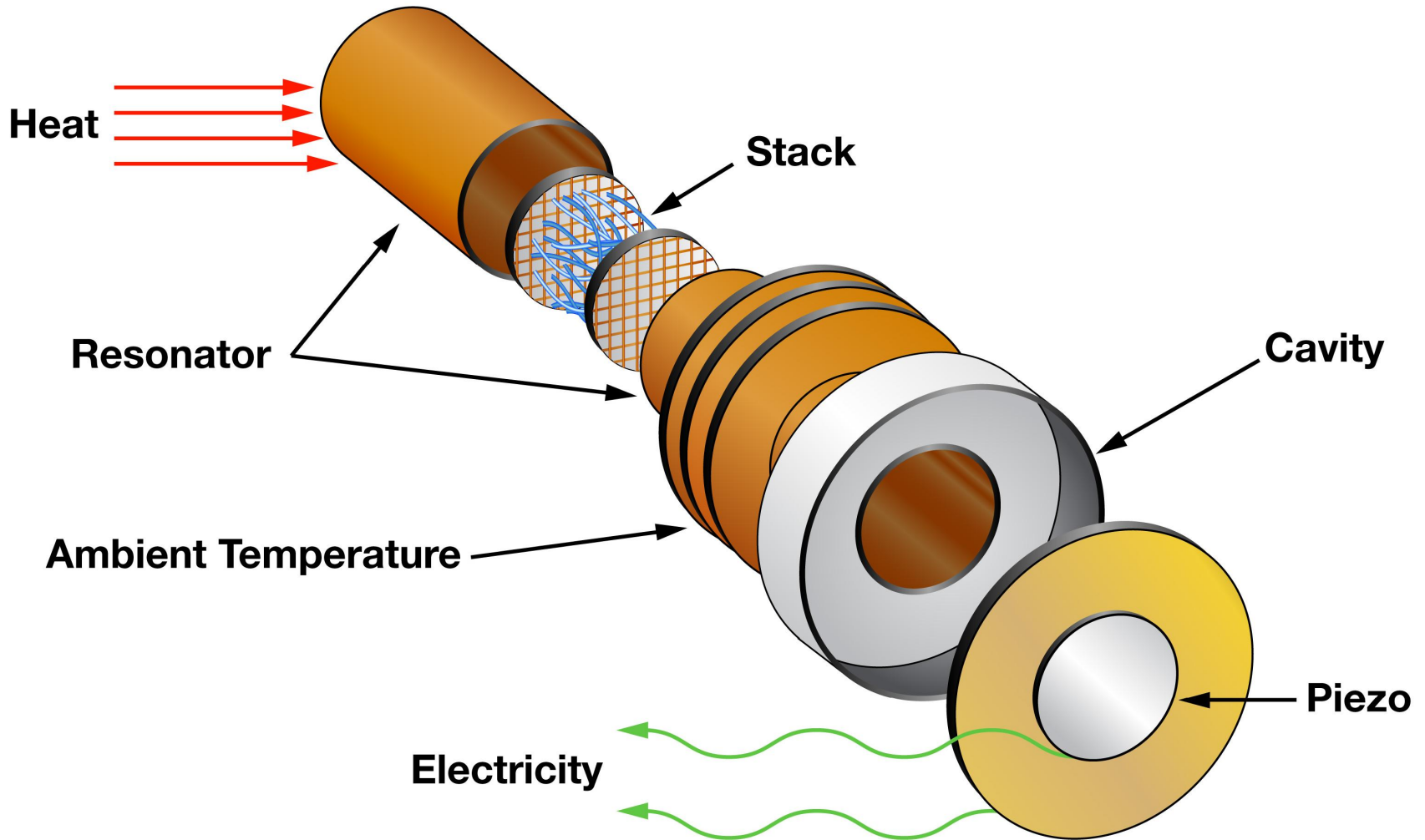
Story of Thermoacoustics





Prof. Orest Symko -- Center for
Acoustic Cooling

THERMOACOUSTIC PRIME MOVER



Prof. Orest Symko -- Center for
Acoustic Cooling

- CENTER GOALS

- **Develop patented thermoacoustic products for:**
 - **Industrial applications**
 - **Military applications**
 - **Research applications**

- POTENTIAL PRODUCTS

A. Short Term (next two years) Products

- **Acoustic coolers & heat pumps**
- **Direct energy converters from heat to electricity**

B. Longer Term Potential Products

- **Waste heat management devices**
- **Thermal management devices**
- **Automatic thermal switches**
- **Arrays of acoustic devices**

• **PATENTS**

- **U.S. Patent on Miniature Thermoacoustic Refrigerator Mini-Refrigerator awarded in 2003, No. 6,574,968 B1, and in 2004, No. 6,804,967 B2.**
- **Thermoacoustic Energy Converter 2001, pending.**
- **3 invention disclosures in preparation:**
 - (i) **automatic thermal switch**
 - (ii) **phase locking of array of acoustic energy converters**
 - (ii) **Impedance change in Piezo Devices for power application.**

- **COMPETITIVE ADVANTAGE**

- **HIGH POWER DENSITY ~ 10 WATTS/CM³**
- **POWER LEVELS ~ 100 WATTS**
- **COOLING POWER DENSITY ~ 10 – 100 WATTS/CM²**
- **ENVIRONMENTALLY SAFE**

- FIRST COMMERCIAL PRODUCTS

1. High performance instrument cooling (Refrigerator)

- **Utah company partner serves military market**

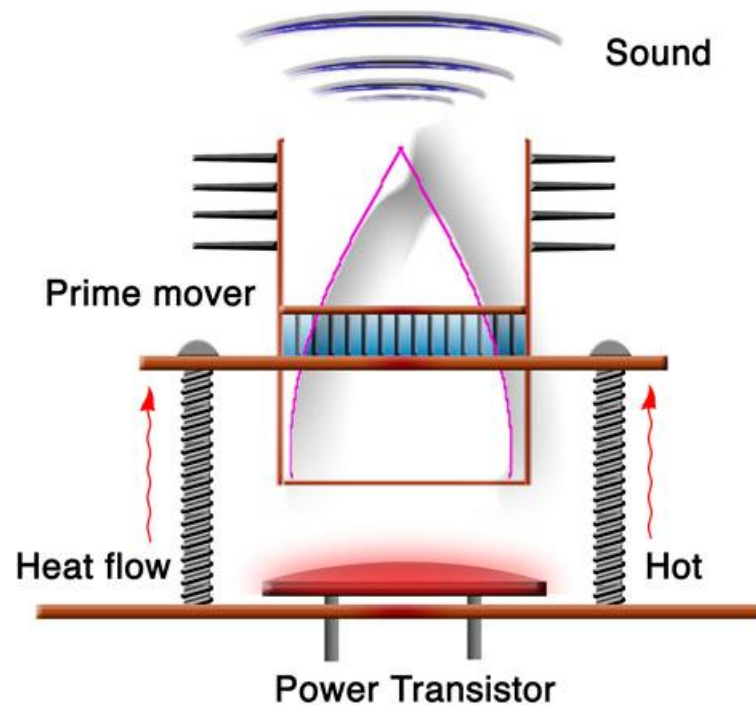
2. Boiler waste heat conversion (Energy Converter)

- **COEN (boiler burner manufacturer)**
- **U of U/COEN beta test**
- **COEN potential distribution partner**

- HIGH PERFORMANCE COOLING WORK

- 1. Pressured units under construction**
 - (10 atmospheres raises cooling by 10 x)
- 2. Development of 5 & 21 kHz refrigerator units**
 - (1 1/4" & 3/8" diameter units)
- 3. Traveling & standing wave mix = higher efficiency**

Sound Radiation by Prime Mover



- COOLING PRODUCT STEPS

- 1. Complete pressurized cooling demo unit**
- 2. Team to design manufacturing of a commercial unit**
- 3. Complete market development activities**
- 4. Complete market strategy and customers**
- 5. Complete an actual beta test**
- 6. Create Utah company or sub-contract manufacturing**
- 7. Implement marketing and distribution strategy**
- 8. One year to product sales**

- COOLING PRODUCT MARKET

Assumptions: (Initial Military Aircraft Only)

- **Source of military aircraft data** <http://www.fas.org/man/dod-101/sys/ac/overview.htm>
- **Total military fighter aircraft at 11,200 (2001)**
- **Each acoustic cooling system sells for \$5,000**
- **Each aircraft requires five units**
- **Retrofit 1,200 per year = 6,000 units/yr**
- **New aircraft at 1,000 per year = 5,000 units/yr**
- **Five year potential market = 55,000 units**

- COOLING PRODUCT MILITARY MARKET

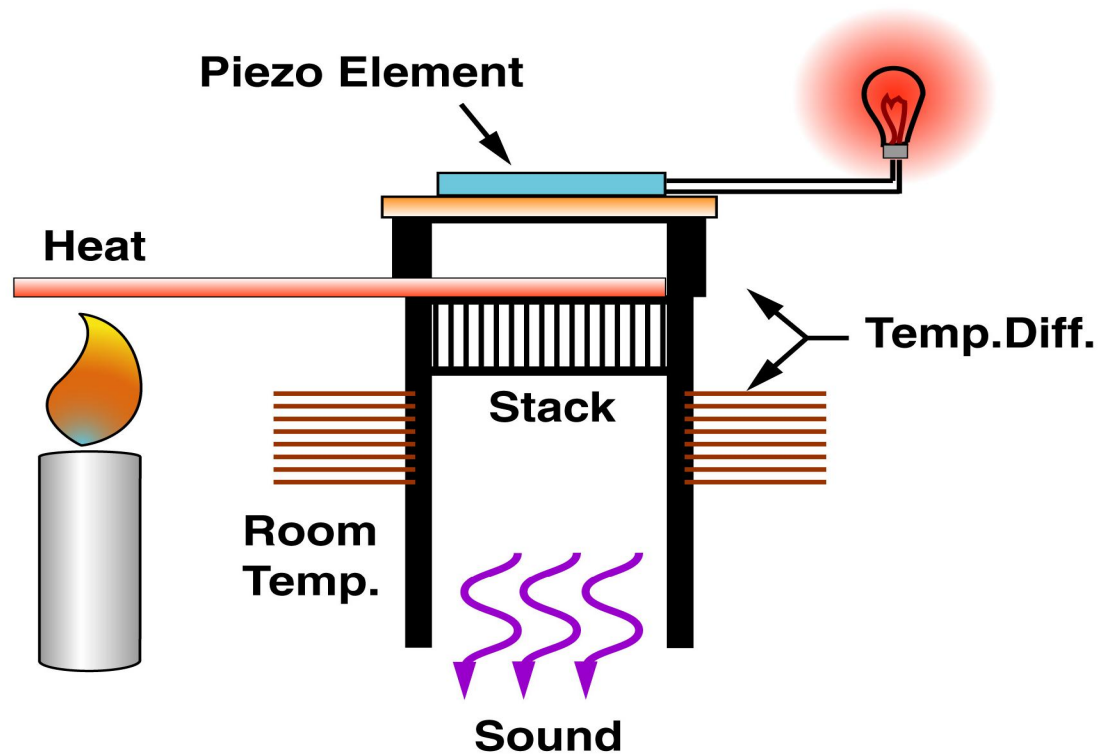
Market Segment	Price per unit	Sales potential in Units	Total potential market
Military Aircraft Instrument Cooling	\$5,000	55,000	\$275,000,000

- **BOILER WASTE HEAT PRODUCT WORK**

heat + **resonator** + piezo = **sound to electricity**

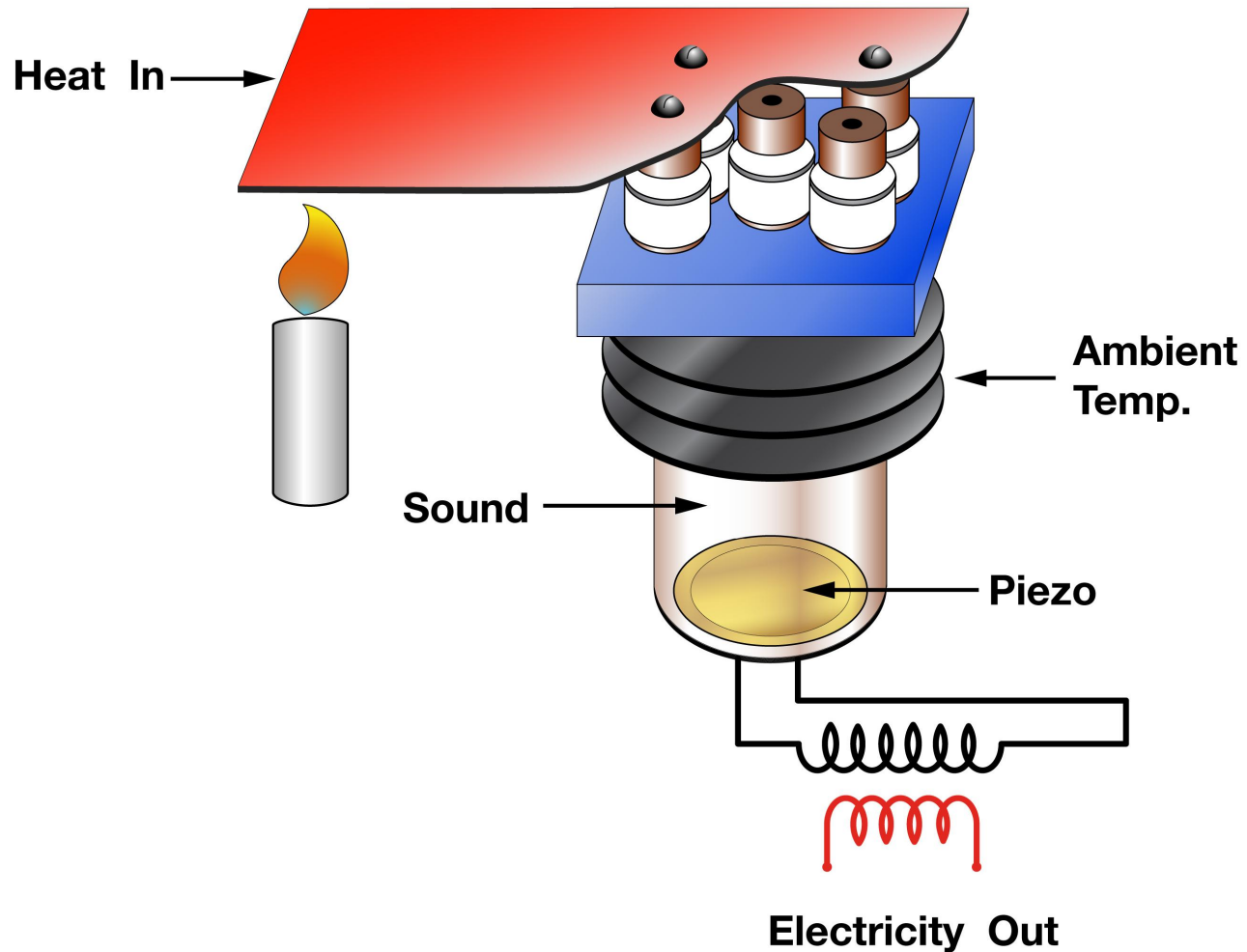
- Lowered piezo impedance (better conversion)
- Arrays for high power density
- Arrays phase-lock for maximum acoustic intensity

BASIC ENERGY CONVERTER



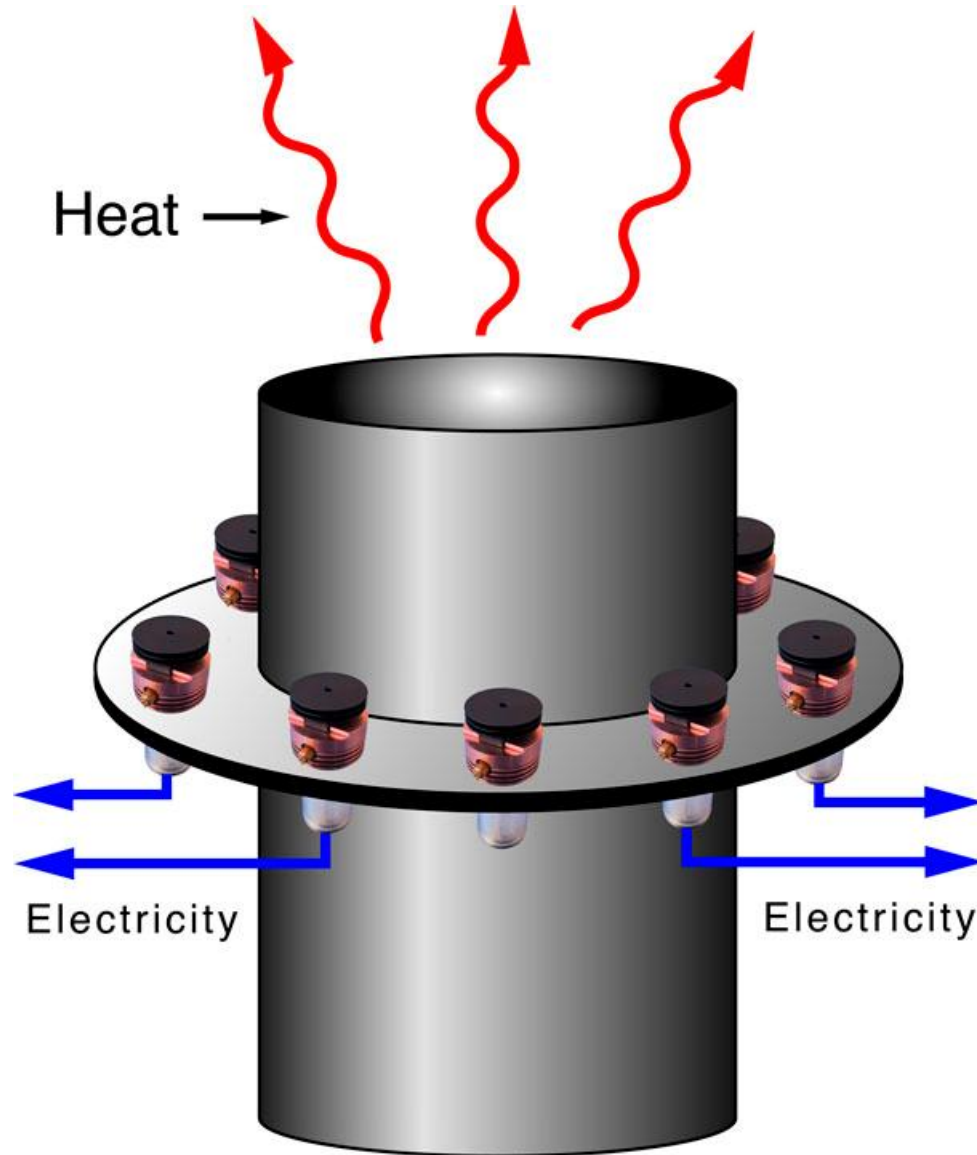
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ENERGY CONVERTER ARRAY



- BOILER WASTE HEAT PRODUCT STEPS

- 1. Complete lab pilot test in conjunction with COEN**
- 2. Design commercial product**
- 3. Complete market development activities**
- 4. Complete market strategy and customers**
- 5. Complete an actual beta test (1 year)**
- 6. Create Utah company or sub-contract manufacturing**
- 7. Implement marketing and distribution strategy**
- 8. Two years to product sales**



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- WASTE HEAT-ENERGY PRODUCT MARKET

Assumptions:

- 1. Source: COEN market research and customer data**
- 2. Initial market applications 22,300 units**
- 3. Secondary boiler applications 26,350 units**
- 4. Average conversion unit installed revenue = \$50,000**
- 5. Average boiler savings per year at \$48,000**
- 6. Basis: 15% cycle efficiency, 688k kw hrs saved @ \$.07**
- 7. Break-even at about 1 year**
- 8. After 5 years est. revenue = 1,250 units (2.5%)=\$62.5M**

- WASTE HEAT-ENERGY PRODUCT MARKET

Market Segment	Price per unit	Sales potential in Units	Total potential market
Primary and Secondary Boilers Waste Heat Energy Conversion	\$50,000	48,650	\$2.432 Billion

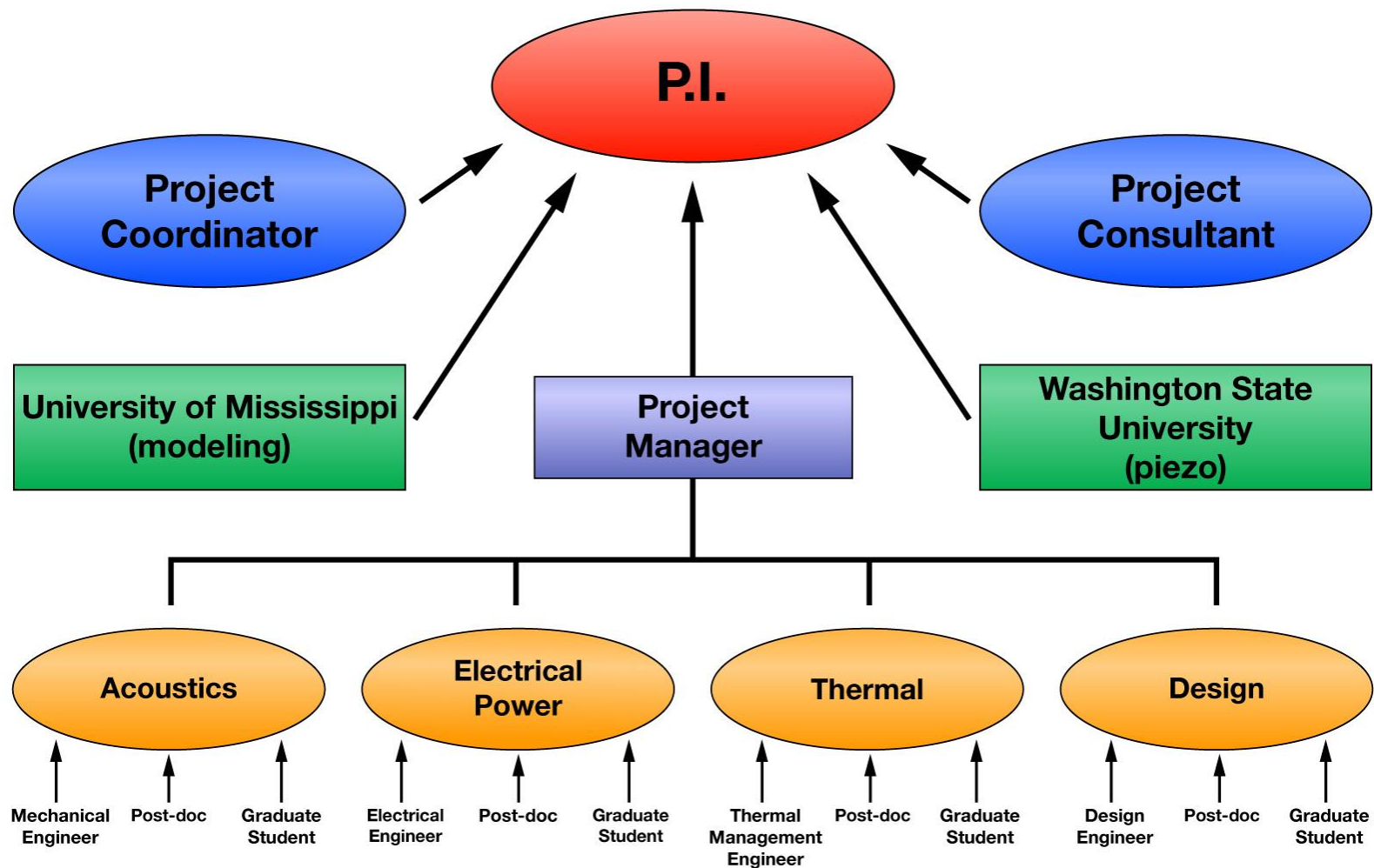
- POTENTIAL BENEFITS TO UTAH

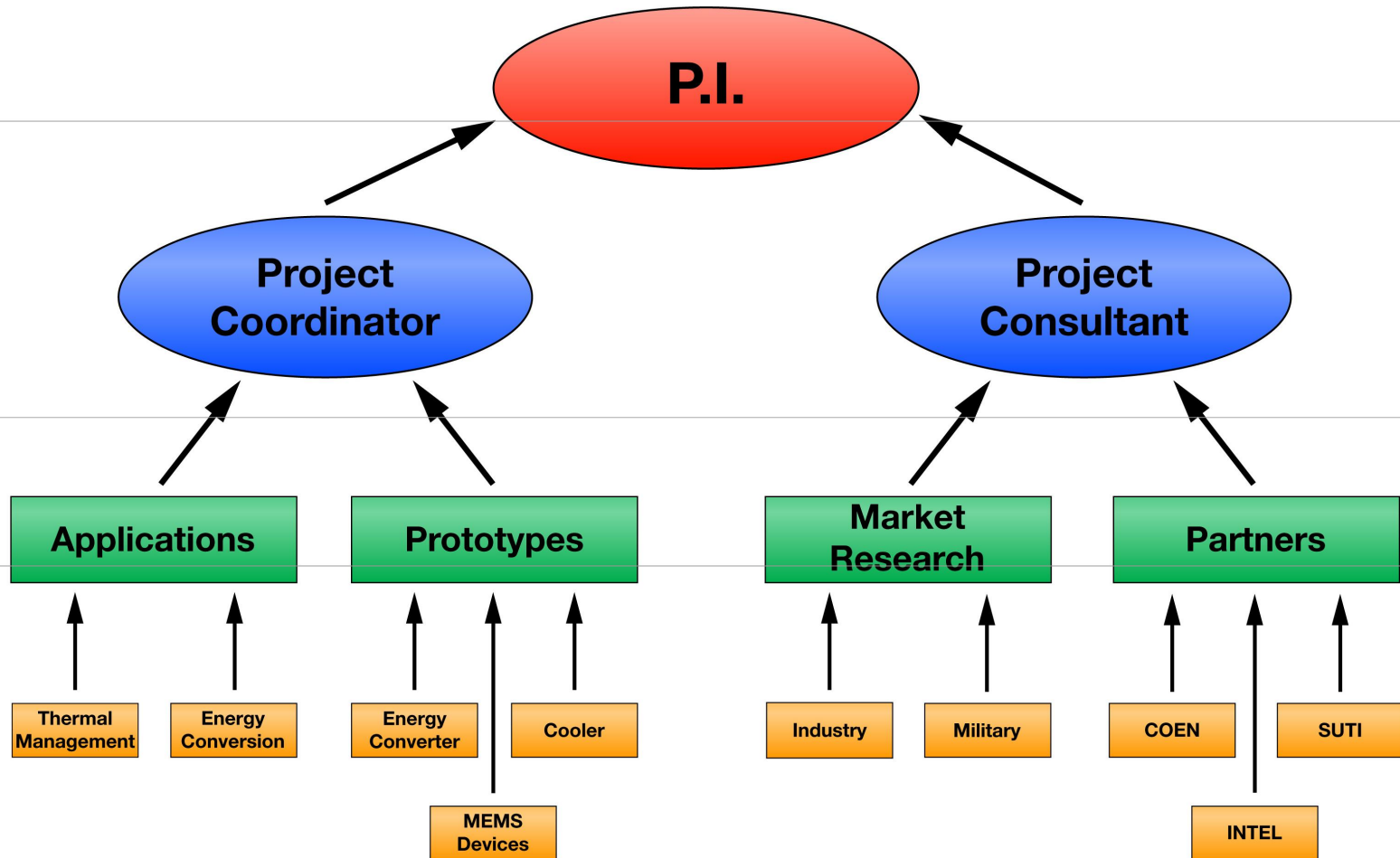
- 1. New Utah Company to manufacture cooling and energy conversion units**
- 2. Basis: \$125,000 sales per FTE**
- 3. After five years: revenue at \$55 M cooling**
- 4. After five years: revenue at \$62.5 M energy units**
- 5. Potential employees at 940+**
- 6. Estimated payroll at \$47 Million**
- 7. Estimated Utah payroll taxes (5%) = \$2.35 Million**

- SOURCES OF FUNDING

- 1. TAPEC DOD line item for technology development
\$1M year 1, \$6.5 M/yr, Years 2-5 (60% net to U of U)**
- 2. Office of Naval Research (ONR), \$150k/yr for 2 yrs**
- 2. COE \$ used solely for commercialization (125k)**
- 3. Potential Venture Capital funds for start up company**

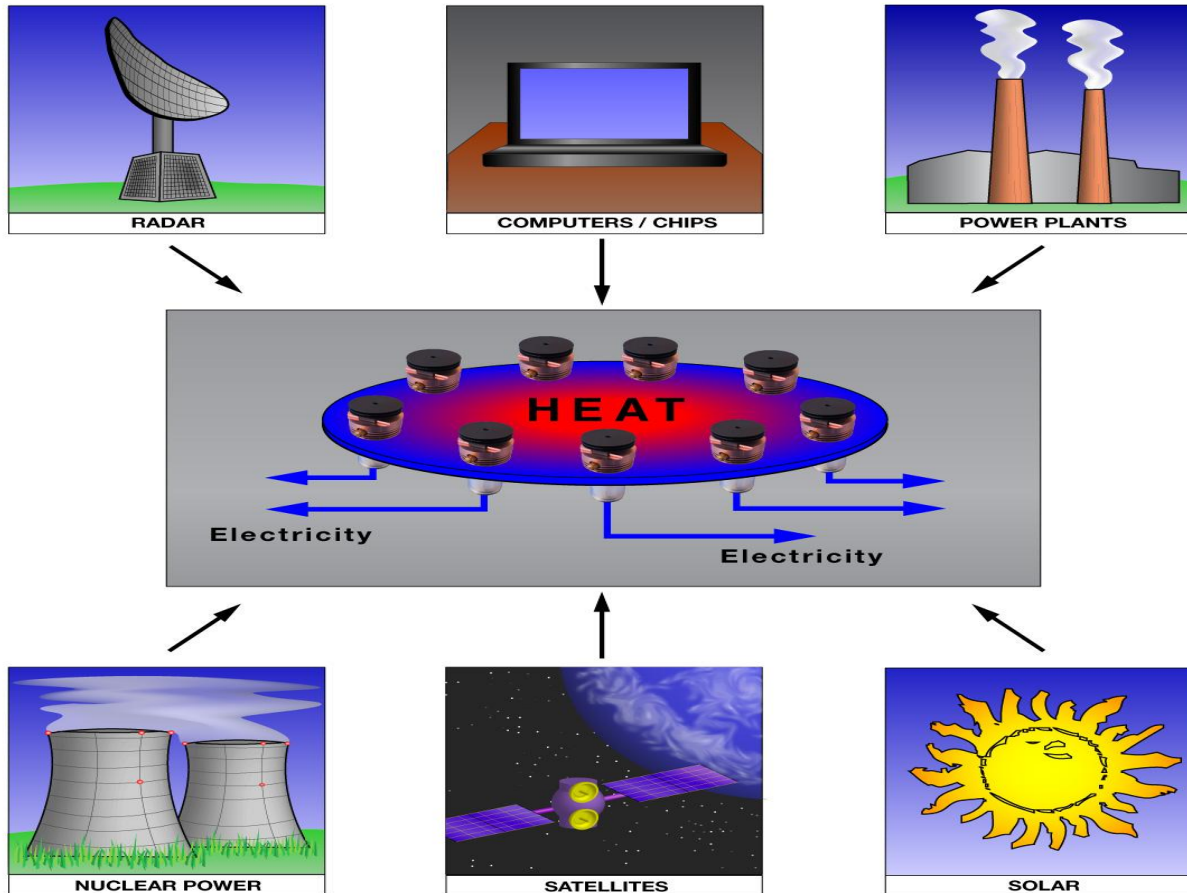
TAPEC





- **IMPORTANCE OF CENTER**

- **Renewable Energy - National Need**
- **Industrial and Military Applications**
- **New, High Power Density for Energy Problems**
- **COE funds used entirely for Commercialization - other grants will be used for development**



- **MANAGEMENT & TECHNICAL TEAMS**

- **Current need for management team members**
- **Current need for expanded technical team**